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6. AUTHOR(S)
Ib A. Svendsen

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Center for Applied Coastal Resesarch, University of Delaware
Newark, DE 19716

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The goal of the project was to develop a computational model for the wave current and sediment transport processes in the Large-scale Ssediment Transport Facility (LSTF), Coastal Hydraulics Laboratory, ERCD, Vicksburg. This involved modifications and further development of the existing quasi-3D nearshore circulation model SHORECIRC (SC) to represent the boundary conditions in the LSTF basin.

It also involved extensive comparisons between computed and measured 3-D current velocities. Finally, the work has included development of a new sediment transport module which has been implemented into the model and tested against the sediment transport measurements conducted so far in the LSTF basin.

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FINAL PROGRESS REPORT

A Computational Model for the Hydrodynamical and Littoral Processes of the Large Scale Sediment Transport Facility at WES

Award No. DAAD19-00-1-0467

Submitted by
Ib A. Svendsen
Center for Applied Coastal Research
University of Delaware
Newark, DE 19716

October 22, 2003

STATEMENT OF THE PROBLEM STUDIED

Research Objectives:

The objective of the project was to create a version of the comprehensive nearshore SHORECIRC circulation model (SC) that simulates flows and sediment motions in the Large-scale Sediment Transport Facility (LSTF) facility, located at the US Corps of Engineers Engineer Research and Development Center in Vicksburg, MS. This facility was designed to analyze the hydrodynamic and littoral processes on natural coasts.

Significance:

During combat operations the construction, maintenance, repair, and rehabilitation of port and logistical facilities are primary responsibilities of Army engineers. This task requires or is highly facilitated by a capability to predict nearshore hydrodynamic phenomena, such as waves, currents, and morphological changes because they constitute a fundamental part of the natural processes on a coast. It is the long-term goal for the project to provide such information.

In the short term, the research will greatly enhance the efficiency of the LSTF experimental facility both in the planning stages of new experiments and in the analysis of the data collected. It will contribute to further verification of the model developed and used in the project and it will help transferring the laboratory results to the conditions on natural beaches in actual combat situations.

SUMMARY OF THE MOST IMPORTANT RESULTS.

Outline of the work

The research work has consisted of model development and comparison to measurements in the LSTF facility. The work can be divided into three major tasks:

(i) improvements of the short wave model that generates the forcing for the currents, essentially the volume flux in the short wave motion and the radiation stresses

(ii) modifications to the model boundary conditions required to properly represent the special in- and outflow conditions for the longshore currents which in the facility is maintained by circulating the water using pumps

(iii) testing of existing sediment transport formulas, development and implementation of a new sediment transport module into the comprehensive hydrodynamic SC-model, and comparison of model results for the sediment transport with measured data from the LSTF facility. Fig. 1 shows the layout of the LSTF.

Brief description of the SHORECIRC model system

The SHORECIRC model is an extension of earlier circulation models such as Ebersole & Dalrymple (1980), Kirby & Dalrymple (1982). Circulation models solve the depth integrated and wave averaged equations and are potentially capable of describing phenomena such as nearshore circulations, rip currents, infragravity waves etc. The early models, however, assume uniformity over depth of all velocities, which the SC-model does not. The SC-model also allows arbitrary bottom topography, has the above mentioned absorbing-generating boundary condition, has a nonlinear shoreline boundary condition, and a general bottom friction model.

The model system essentially consists of three major elements:

1. A component that solves the short wave averaged equations (modified to include the effect of the current profiles) giving a 2D-horizontal variation of the current/IG-wave pattern.

2. A component that evaluates the analytical solutions to the vertical distribution of horizontal velocities in the time varying currents/infra-gravity waves.

3. A short wave model (``wave driver") which determines the short wave forcing for the equations in 1) and 2) by calculating the radiation stresses, mass fluxes etc. of the short period wave motion.

The original SC-model system is using a normal rectangular grid with a robust, high order numerical scheme. The model has also (under a different project) been extended to a version based on a curvilinear grid, which will further enhance its capabilities for adjusting to situations encountered in actual engineering problems. (Shi et al 2003)

The quasi 3-D SHORECIRC (SC for short) model is the only such model available for nearshore circulations. The 3-D current data from the LSTF represent the first time such measurements have been obtained under controlled laboratory conditions. Hence this data set constitutes a unique opportunity to test the 3-D capabilities of the model system.

From an early stage of the work the SC model has been made available to the LSTF group, and since June 2002 it has been available to the engineering community on the software web site of the Center for Applied Coastal Research, University of Delaware.

Work on Task (i): The first steps toward achieving (i) were taken during the first reporting period (July 1 2000 - Jan 31 2001) and reported in the interim report for that period. The work on this task was essentially finished in the second reporting period (Feb 1 2001 - Dec 31 2001). It included work on the new wave model and comparisons with other wave data sets. In addition to the comparisons to measured wave height and setup data, the comparisons included the 3-D wave generated circulation currents.

The work was published in Qin and Svendsen (2001).

Work on task (ii): Work on task (ii) aimed at developing methods for modelling the special cross-shore boundary conditions in the basin, where the obliquely incident waves generate strong longshore currents. To produce longshore uniform flow patterns over the limited length of the basin, the correct cross-shore distribution of the longshore currents must be imposed artificially along both the upstream and the downstream cross-shore boundaries. The work on this task was also finished and reported in the second reporting period (Feb 1 2001 - Dec 31 2001).

Publication of the work in Task i) and ii): The work of tasks i) and ii) was published in Qin and Svendsen (2001) and in Svendsen et al. (2003).

Work on Task (iii): The work in the third and last reporting period (Jan. 1, 2002 - July 31, 2003) has mainly consisted in continuing the development of the sediment transport module started in the previous reporting period, and in testing and implementing the module into the SC-model system (task (iii)). The work also included expanding the kinematic wave model used in the first part of the project to application also on irregular waves. Finally, work was conducted on testing existing sediment transport formulas.

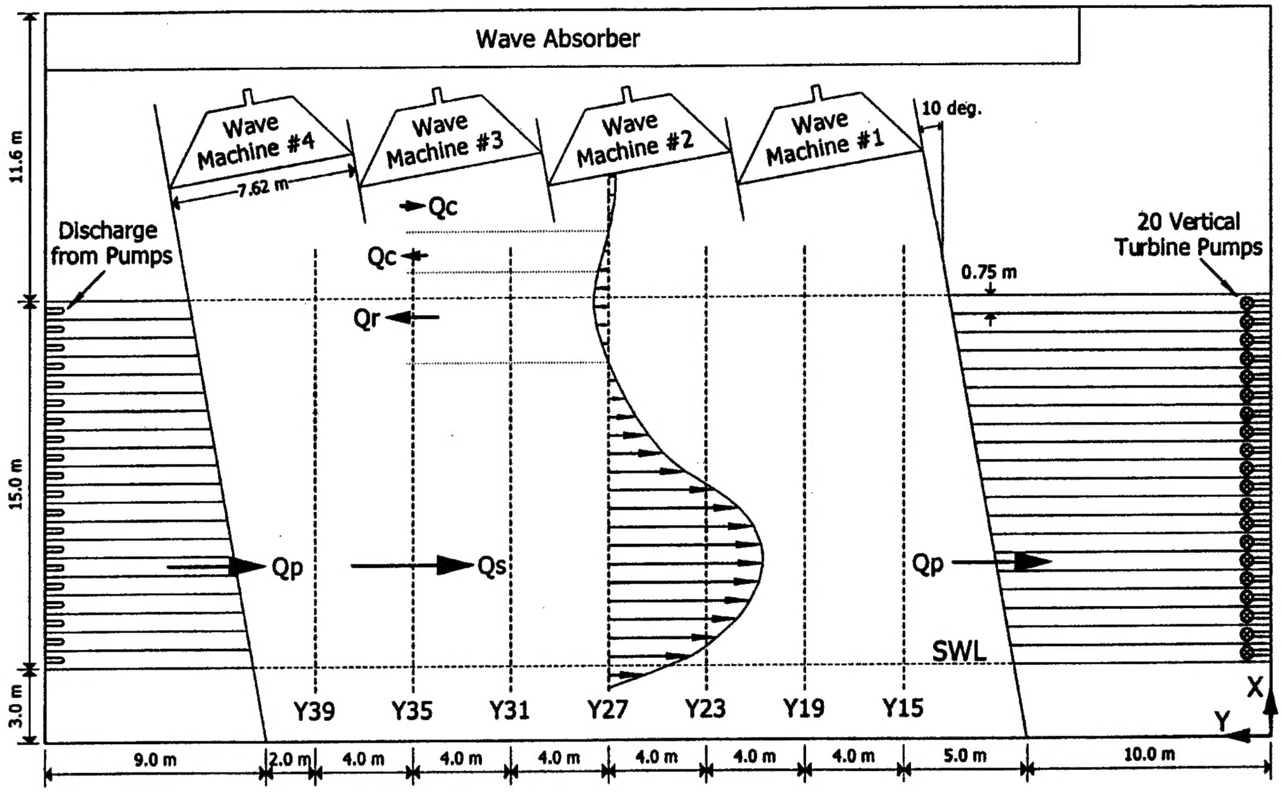

Figure 1: Layout of the Large-scale Sediment Transport Facility at the Army Corps of Engineers Engineer, Research and Development Center. The four wave makers generate large-scale waves moving toward and breaking on the beach at the bottom of the figure. In the process strong longshore currents are generated. Extensive measurements of waves and currents form the basis for the model comparisons.

The new sediment transport module implemented into the comprehensive SC model consists of two components: an element that determines how much sediment is being moved at each point in the computational domain, and an element that determines the morphological changes caused by the calculated sediment motions.

The computed results have been compared to the measurements from the LSTF facility, which contains results for many points along one cross-shore transect in the LSTF basin. Fig 2 shows results for the vertical distribution of the sediment concentrations generated by the combined wave and current motions at two points along the transect (x = 6.38 m and x = 12.28 m). It may be noticed that the concentration scale is logarithmic. Therefore the good agreement at the lower part of the profiles, where the concentrations are high, is more important for the overall transport rate than the less good agreement in the upper part, where the concentrations are much smaller. The longshore (or cross-shore) sediment transport rate is determined by integrating over the depth the product of these concentrations and the longshore (or cross-shore) water velocity

obtained from the hydrodynamical model (and adding the bedload transport which is small in these experiments).

The results for the total depth integrated longshore transport rates are shown for the entire cross-shore transect in Fig 3. In this figure the beach is to the right at about x = 18 m. The total longshore sediment transport rate is represented by the area under the curve (calculated) or the points (measured). We see that although there are some (not yet understood) discrepancies in the region closest to the shoreline, the two areas under the curve/points are quite similar meaning overall prediction of the longshore transport rate is good.

Description of the work has been published in Qin et al. (2002) and a more detailed version will appear in Qin et al. (2003) and in Qin & Svendsen (2003). These publications are scheduled to be finished before the end of 2003. The testing of existing sediment transport formulas is being published in Haas & Hanes (2003).

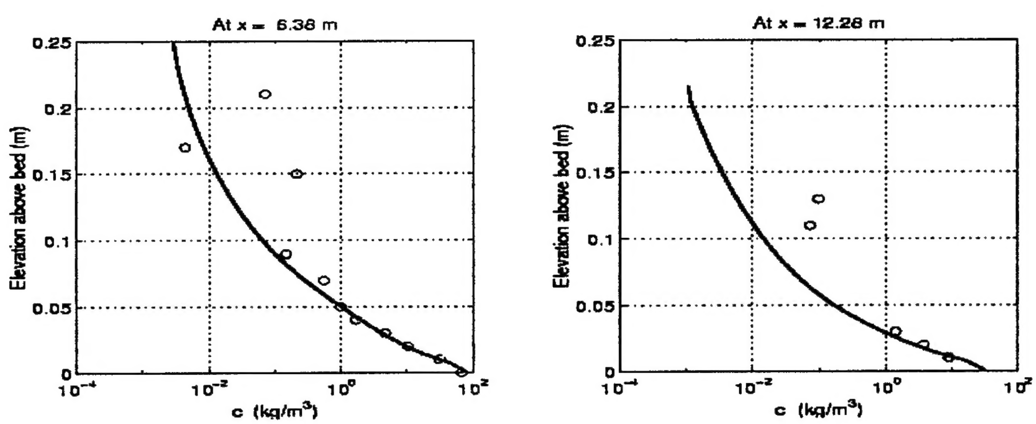

Fig 2. Comparison of the vertical profiles of the time averaged concentrations. Circles are the measurements, the curve the computations.

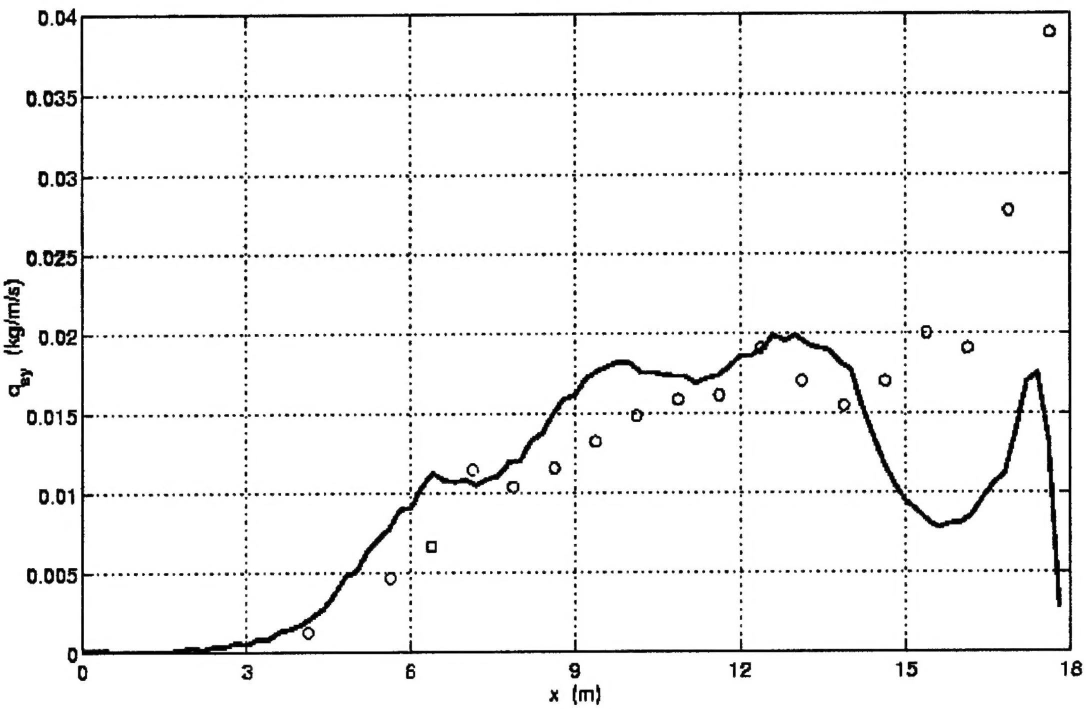

Fig 3. Comparison of the cross-shore variation of the depth integrated values of the longshore sediment transport for measurements (circles) and computations (curve).

Technology transfer

During the work the PI and his team have stayed in frequent contact with the personnel at the Coastal Hydraulics Laboratory, Vicksburg MS who operate the LSTF facility, in particular Bruce Ebersole, Chief, Coastal Processes Branch, Dr. Jane Smith and Ernie Smith, Coastal Processes Branch. Experimental data from the hydrodynamic and sediment transport experiments with the new facility have been transferred to us and used for the work described in this report. In January 2002, the PI and Wenkai Qin participated in a 2 day workshop at the LSTF facility in Vicksburg, gave two seminars about the work ongoing with the project and its perspectives for nearshore modelling, and joined extensive discussions about the problems related to the experiments, their

interpretation, and the modelling of the flows and the morphological processes measured in the tank.

LIST OF PUBLICATIONS AND TECHNICAL REPORTS

Qin, W., I. A. Svendsen (2001). Comparison of nearshore wave characteristics between theories and lab experiments. *Proc. ASCE Int. Conf. Coastal Dynamics 2001*, Lund, Sweden, June 10-12, 2001, 345-354.

Svendsen, I. A., W. Qin, and B. Ebersole (2002). Modelling waves and currents in the LSTF facility. Journal paper accepted for publication in Coastal Engineering in 2003. In press.

Shi, F., I. A. Svendsen, J. T. Kirby and J. McKee Smith (2003). A curvilinear version of a quasi-3D nearshore circulation model. *Coast. Engineering*, 49, 99-124.

Qin, W., I. A. Svendsen, B. Ebersole, and E. R. Smith (2002). Modelling sediment transport at the LSTF at CHL. *Proc. ASCE Int. Conf. Coastal Engineering,* Cardiff, UK, July 2002, 3020-3032.

Haas, K., and D. Hanes (2003). Process based modeling of total longshore sediment transport. To appear in *Journal of Coastal Research*.

Qin, W., and I. A. Svendsen (2003). Modelling nearshore waves, currents and sediment transport. *CACR Report 03-04*, Center for Applied Coastal Research,Univeristy of Delaware, November 2003.

Qin, W., I. A. Svendsen, B. Ebersole (2003). Sediment transport at the LSTF facility under irrgular waves. Journal paper in preparation

SCIENTIFIC PERSONNEL

Ib A. Svendsen (PI)
Distinguished Professor of Ocean Engineering
Center for Applied Coastal Research
Department of Civil and Environmental Engineering
University of Delaware
Neawark, DE 19716, USA
Phone: (302) 831-2449
FAX: (302) 831-1228
ias@coastal.udel.edu
URL: www.coastal.udel.edu/~ias

Wenkai Qin, Ph.D. student
Center for Applied Coastal Research
University of Delaware

Kevin A. Haas, Post Doctoral Fellow
Center for Applied Coastal Research
University of Delaware